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PATENT
Attorney Docket: 1094-12

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

APPELLANT(S): Karrs et al.

GROUP: 1764

SERIAL NO.: 09/973,401

EXAMINER: Thanh P. Duong

FILED: October 9, 2001

FOR: MODULAR SYSTEM AND METHOD FOR THE CATALYTIC TREATMENT OF A GAS STREAM

Dated: January 23, 2006

Mail Stop: Appeal Brief-Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

TRANSMITTAL OF APPELLANTS' BRIEF

Sir:

This Brief is being submitted in triplicate pursuant to 37 C.F.R. § 1.192. The Notice of Appeal was mailed on September 28, 2005.

CERTIFICATE OF MAILING UNDER 37 C.F.R. '1.8(a)

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail, postpaid in an envelope addressed to the: Mail Stop: Appeal Brief-Patents, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Dated: January 23, 2006

Adrian T. Calderone

Enclosed is a check in the sum of $500 for filing a brief in support of an appeal.

Please charge any additional fee(s) under 37 C.F.R. § 1.17(f) or credit any overpayment to Deposit Account No. 04-1121. Also in the event that any extensions of time are required, please treat this paper as a petition to extend the time as required and charge Deposit Account No. 04-1121. A DUPLICATE COPY OF THIS SHEET IS ENCLOSED.

Respectfully submitted,

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APPELLANTS' BRIEF

Sir:

This appeal is taken in view of the final rejection of the claims in the final Office Action dated June 28, 2005 and the Notice of Panel Decision from Pre-Appeal Brief Review dated November 23, 2005.

CERTIFICATE OF MAILING UNDER 37 C.F.R. '1.8(a)

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail, postpaid in an envelope addressed to: Mail Stop: Appeal Brief-Patents, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Dated: January 23, 2006

Adrian T. Calderone

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STATUTES AND REGULATIONS

I. Real Party in Interest

This application is assigned to ABB Lummus Global Inc..

II. Related Appeals and Interferences

None

III. Status of Claims

Claims 1-38 are rejected

Claims 39-49 are cancelled.

Claims 50-57 are rejected.

Claims on appeal include claims 1-38 and 50-57.

IV. Status of Amendments

No amendments were filed by Appellants after the final Office Action.

V. Summary of Claimed Subject Matter

The present invention relates to a system for catalytically treating a gas stream, and particularly to a system for catalytically reducing the content of undesirable compounds such as nitrogen and/or sulfur oxides in a flue gas resulting from the combustion of fuel. A summary of the individual claims is set forth below in Table 1. See specification page 1, lines 1-7, and Fig. 1 of the drawings.

Table 1

Claims	Support
1. A system for catalytically treating a gas stream, which comprises: a) a gas phase reactor containing a catalyst for the treatment of the gas stream in at least one catalyst bed having an upstream end and a downstream end;	See, for example, Fig. 1 of the drawings and page 13, line 10 *et seq.* of the specification, and description of reactor system 400, and catalyst beds 410 and 420 at pages 17-18.
b) an axial fan positioned upstream of the at least one catalyst bed and having a rotatable impeller for moving the gas stream through the gas phase reactor; and,	See, fan system 100, impeller assembly 130 , Figs. 2 and 3 of the drawings, and page 8, line 1 to page 10, line 10 of the specification.
c) gas flow modification means positioned between the impeller and the gas phase reactor for decreasing gas stream velocity and increasing gas flow uniformity.	See generally, page 12, line 6 to page 14, line 24, and Figs 1 and 2 of the drawings. Particularly, note gas flow modification means can include tapered tail cone 140, guide vanes 310, and transition duct 310 with perforated walls 321.
2. The system of claim 1 wherein the gas flow uniformity is increased by the gas flow modification means such that the gas stream entering the gas phase reactor has a velocity profile exhibiting not more than about 10% velocity deviation from an average gas stream velocity at the upstream end of the at least one catalyst bed.	See page 11, lines 18 to 24.
3. The system of claim 2 wherein the velocity profile of the gas stream exhibits no more than about a 5% velocity deviation from an average gas stream velocity at the upstream end of the at least one catalyst bed.	See page 11, lines 18 to 24.

4. The system of claim 1 wherein the axial fan includes a housing and a tail cone, and the gas flow modification means includes a distally pointing tapered end portion of the tail cone and a flared portion of the housing having a gradually increasing diameter.	See, Figs. 1 and 2 and specification page 12, lines 6-20.
5. The system of claim 4 wherein the gas flow modification means further includes a transition duct having perforated walls which flare outward so as to gradually increase cross-sectional area available to gas stream flow.	Fig. 1 and specification page 14, lines 5-13.
6. The system of claim 1 wherein the gas flow modification means includes a transition duct having perforated walls which flare outward so as to gradually increase cross-sectional area available to gas stream flow.	Fig. 1 and specification page 14, lines 5-13.
7. The system of claim 1 further including means for recycling a portion of the gas stream from downstream of the axial fan to a position upstream of the axial fan.	Fig. 1 and specification page 15, lines 1-20.
8. The system of claim 1 wherein the gas stream contains nitrogen oxide.	Specification, page 5, lines 15-18.
9. The system of claim 1 wherein the catalyst bed includes a plurality of stackable, individually separable modules containing one or more materials selected from the group consisting of vanadium oxide, aluminum oxide, titanium oxide, tungsten oxide, molybdenum oxide and zeolite.	Figs. 1, 5 and 6 and specification page 15, line 21 to page 18, line 21.
10. The system of claim 9 wherein the modules each comprise a plurality of stacked catalyst elements having a honeycomb type structure.	Fig. 5, specification page 16, line 17 to page 17, line 65.
11. The system of claim 1 wherein the catalyst bed comprises a catalyst supported on a mesh-like structure having a void space of at least about 85%.	Specification, page 17, lines 6-21.
12. The system of claim 1 wherein the catalyst bed includes a vanadium pentoxide catalyst on titanium oxide support.	Specification page 17, lines 12-13.
13. The system of claim 1 wherein the gas phase reactor comprises at least two catalyst beds arranged in series.	Specification page 20, line 20.

14. The system of claim 1 wherein the fan impeller includes a plurality of blade units attached to and extending radially outward from a circumferential periphery of the impeller.	Fig. 3 and specification page 8, line 22 to page 9, line 14.
15. The system of claim 14 wherein the blade units each comprise two blades.	See, page 9, lines 5-14 of the specification and Fig. 4 of the drawings
16. The system of claim 14 wherein the blade units have a variable pitch which is controllable while the impeller is rotating.	Specification page 9, lines 17-23.
17. The system of claim 14 wherein the impeller has a variable speed of rotation which is adjustable while the impeller is rotating.	Specification, page 10, lines 1-3.
18. The system of claim 1 further including a heat recovery section positioned downstream of the gas phase reactor for cooling the gas stream.	Specification, page 19, lines 4-17, and Fig. 1.
19. The system of claim 1 further including means for introducing reducing agent into the gas stream.	Fig. 1, and specification page 15, lines 1-6.
20. The system of claim 19 further including a gas stream recycle manifold for communicating a portion of the gas stream downstream of the axial fan to a convection section of a furnace positioned upstream of the axial fan, wherein the means for introducing reducing agent comprises an inlet for introducing the reducing agent into the gas stream recycle manifold.	Fig. 1 and specification page 15, lines 1-20.
21. A system for catalytically treating a furnace flue gas, which comprises: a) a gas phase reactor containing a catalyst for the treatment of the flue gas in at least one catalyst bed having an upstream end and a downstream end;	See, Fig. 1 of the drawings and page 13, line 10, *et seq.* of the specification, and description of the reactor system 400 and catalyst beds 410 and 420 at pages 17-18
b) an axial fan positioned upstream of the at least one catalyst bed and downstream of a furnace and having a rotatable impeller for moving the flue gas from the furnace through the gas phase reactor; and,	See, fan system 100, impeller assembly 130, Figs. 2 and 3 of the drawings, and page 8, lines 1 to page 10, line 10 of the specification
c) means for recycling a portion of the flue gas from downstream of the axial fan to a convection section of the furnace located upstream of the axial fan.	See Fig. 1 of the drawings and page 15, lines 1-20

22. The system of claim 21 wherein the means for recycling a portion of the flue gas comprises a gas stream recycle manifold.	Specification page 15, lines 1-20 and Fig. 1
23. The system of claim 22 wherein the gas stream recycle manifold includes an inlet for introducing reducing agent into recycle manifold.	Fig. 1, and specification page 15, lines 1-6.
24. The system of claim 22 wherein the gas stream recycle manifold includes a control valve.	Fig. 1 and specification page 15, lines 11-13.
25. The system of claim 22 further comprising a transition duct having perforated walls which flare outward so as to gradually increase cross-sectional area available to flue gas flow.	Fig. 1 and specification page 14, lines 5-13.
26. The system of claim 25 wherein the gas stream recycle manifold has at least one inlet connected to the transition duct, and at least one outlet connected to the convection section of the furnace.	Fig. 1 and specification page 15, lines 1-20.
27. The system of claim 21 wherein the axial fan includes a housing and a tail cone, the housing having a flared distal portion and the tail cone having a distally pointing tapered end portion.	Fig. 2, and specification page 12, lines 6-20.
28. The system of claim 21 wherein the catalyst bed includes a plurality of stackable, individually separable modules containing one or more materials selected from the group consisting of vanadium oxide, aluminum oxide, titanium oxide, tungsten oxide, molybdenum oxide and zeolite.	Figs. 1 and 6, and specification page 16, lines 6-16, and page 18, lines 1-13.
29. The system of claim 28 wherein the modules each comprise a plurality of stacked catalyst elements having a honeycomb type structure.	Fig. 5 and specification page 16, lines 19-23.
30. The system of claim 21 wherein the catalyst bed comprises a catalyst supported on a mesh-like structure having a void space of at least about 85%.	Specification page 17, lines 6-21.
31. The system of claim 21 wherein the flue gas contains nitrogen oxide.	Specification, page 5, lines 17-19, page 6, *et seq.*
32. The system of claim 31 wherein the at least one catalyst bed includes a vanadium pentoxide catalyst on titanium oxide support.	Specification page 11, lines 12-13.

33. The system of claim 21 wherein the gas phase reactor comprises at least two catalyst beds arranged in series.	Specification, page 20, line 20.
34. The system of claim 21 wherein the fan impeller includes a plurality of blade units attached to and extending radially outward from a circumferential periphery of the impeller.	Fig. 3, and specification page 8, line 22 to page 9, line 14.
35. The system of claim 34 wherein the blade units each comprise two blades.	Page 9, lines 5-14 of the specification and Fig. 4 of the drawings.
36. The system of claim 34 wherein the blade units have a variable pitch which is controllable while the impeller is rotating.	Specification, page 9, lines 17-23.
37. The system of claim 34 wherein the impeller has a variable speed of rotation which is adjustable while the impeller is rotating.	Specification page 10, lines 1-3.
38. The system of claim 21 further including a heat recovery section positioned downstream of the gas phase reactor for cooling the flue gas.	Specification page 19, lines 4-17, and Fig. 1.
50. The system of claim 1, wherein the gas flow modification means comprises: a housing including a tail cone, wherein the housing surrounds the axial fan, and wherein the tail cone is positioned downstream from the axial fan; and,	See Figs. 1 and 2 and specification page 12, lines 6-20.
a transitional duct having perforated walls that are flared outward disposed downstream from the housing.	Specification page 14, lines 5-13 and Fig. 1.
51. The system of claim 50, wherein the tail cone has a substantially conical shape and comprises a distally pointing tapered end portion.	Fig. 2, specification page 12, lines 9-13.
52. The system of claim 51; wherein the tail cone is supported within the housing by longitudinally oriented planar struts positioned in an annular space between the tail cone and an interior surface of the housing, wherein the struts act as baffles to reduce swirl and direct gas flow towards an axial flow of the flue gas through the system.	Fig. 2, specification page 12, lines 13-20.

53. The system of claim 50, wherein the housing further comprises: an outlet, wherein a diameter of the outlet is greater than a diameter of an impeller of the axial fan, and wherein the circumference of the housing gradually increases from a position of the housing at the axial fan to the outlet of the housing.	Specification page 12, line 21 to page 13, line 9.
54. The system of claim 50, wherein the gas flow modification means further comprises a guide vane unit disposed at an inlet of the transition duct, wherein the guide vane unit includes louvers for redirecting the flow of the flue gas.	Fig. 1 and specification page 13, lines 17-23.
55. The system of claim 4, wherein the gas flow modification means further comprises: a transition duct having perforated walls that flare outward positioned downstream from the housing; and,	Fig. 1 and specification page 14, lines 1-10.
a guide vane unit disposed at an inlet of the transition duct, wherein the guide vane unit includes louvers for redirecting the flow of the flue gas.	Fig. 1 and specification page 13, lines 17-23.
56. The system of claim 6, wherein the gas flow modification means further comprises: a transition duct having perforated walls that flare outward positioned downstream from the housing; and,	Fig. 1 and specification page 14, lines 5-13.
a guide vane unit disposed at an inlet of the transition duct, wherein the guide vane unit includes louvers for redirecting the flow of the flue gas.	Fig. 1 and specification page 13, lines 17-23.
57. The system of claim 27, wherein the gas flow modification means further comprises: a transition duct having perforated walls that flare outward positioned downstream from the housing; and,	Fig. 1 and specification page 14, lines 5-13.
a guide vane unit disposed at an inlet of the transition duct, wherein the guide vane unit includes louvers for redirecting the flow of the flue gas.	Fig. 1 and specification page 13, lines 17-23.

VI. Grounds of Rejection to be Reviewed on Appeal

The following references are cited in support of the rejections of the claims as listed below.

European Patent Application 0166480 (hereinafter, "EU '480")

U.S. Patent No. 5,282,355 (hereinafter, "Yamaguchi")

U.S. Patent No. 5,632,142 (hereinafter, "Surette")

U.S. Patent No. 2,936,846 (hereinafter "Tyler et al.")

U.S. Patent No. 5,043,146 (hereinafter, "Ishikawa et al.")

U.S. Patent No. 5,397,545 (hereinafter, "Balling et al.")

U.S. Patent No. 6,534,022 (hereinafter, "Carlborg")

U.S. Patent No. 5,709,088 (hereinafter, "Acaster")

U.S. Patent No. 5,476,378 (hereinafter, "Zagoroff et al.")

An "admission" in Appellants' specification at page 9, lines 15-23 (hereinafter, "Admission").

The issues raised by the rejections are as follows:

1. Whether Claims 1-3, 8, 14 and 15 are anticipated under 35 U.S.C. 102(b) by European Patent Application 0166480 ("EU '480").

2. Whether Claims 1 and 21-23, 31, 34-35 and 38 are anticipated under 35 U.S.C. §102(b) by U.S. Patent No. 5,282,355 ("Yamaguchi").

3. Whether Claims 2-3 are obvious under 35 U.S.C. §103(a) over EU '480.

4. Whether Claim 4 is obvious under 35 U.S.C. §103(a) over EU '480 in view of U.S. Patent No. 5,632,142 ("Surette").

5. Whether Claims 5, 50, 51 and 53-55 are obvious under 35 U.S.C. §103(a) over EU '480 in view of Surette and further in view of U.S. Patent No. 2,936,846 ("Tyler et al.") and U.S. Patent No. 5,043,146 ("Ishikawa et al.").

6. Whether Claims 6 and 56 are obvious under 35 U.S.C. §103(a) over EU '480 in view of Tyler et al. and Ishikawa et al.

7. Whether Claims 7 and 18-20 are obvious under 35 U.S.C. §103(a) over EU '480 in view of Yamaguchi.

8. Whether Claims 9-10 and 12-13 are obvious under 35 U.S.C. §103(a) over EU '480 in view of U.S. Patent No. 5,397,545 ("Balling et al.").

9. Whether Claim 11 is obvious under 35 U.S.C. §103(a) over EU '480 in view of U.S. Patent No. 6,534,022 ("Carlborg et al.").

10. Whether Claim 16 is obvious under 35 U.S.C. §103(a) over EU '480 in view of an "Admission" in applicants' specification at page 9, lines 15-23.

11. Whether Claim 17 is obvious under 35 U.S.C. §103(a) over EU '480 in view of U.S. Patent No. 5,709,088 ("Acaster").

12. Whether Claims 21-24 are obvious under 35 U.S.C. §103(a) over EU '480 in view of Yamaguchi.

13. Whether Claims 25 and 26 are obvious under 35 U.S.C. §103(a) over EU '480 in view of Yamaguchi and further in view of Tyler et al. and Ishikawa et al.

14. Whether Claims 25 and 26 are obvious under 35 U.S.C. §103(a) over Yamaguchi in view of Tyler et al. and Ishikawa et al.

15. Whether Claim 27 is obvious under 35 U.S.C. §103(a) over Yamaguchi in view of Surette.

16. Whether Claim 30 is obvious under 35 U.S.C. §103(a) over Yamaguchi in view of Carlborg et al.

17. Whether Claims 28-29 and 32-33 are rejected under 35 U.S.C. §103(a) as being obvious over Yamaguchi in view of Balling et al.

18. Whether Claim 36 is obvious under 35 U.S.C. §103(a) over Yamaguchi in view of "Admission".

19. Whether Claim 37 is obvious under 35 U.S.C. §103(a) over Yamaguchi in view of Acaster.

20. Whether Claim 52 is obvious under 35 U.S.C. §103(a) over EU '480 in view of Surette and Tyler et al. and Ishikawa et al., and further in view of U.S. Patent No. 5,476,378 ("Zagoroff et al.").

21. Whether Claim 57 is obvious under 35 U.S.C. §103(a) over EU '480 in view of Surette and further in view of Tyler et al. and Ishikawa et al.

VII. Argument

In the multitude of rejections to which Appellants have been obliged to respond below, the Examiner has repeatedly made unsupported assertions and conclusory statements in characterizing what the prior art references disclose. Such assertions and statements cannot be given any weight. Rejections must be based upon the objective evidence of record. *In re Lee*, 61 USPQ2d 1430, 1433 (Fed. Cir. 2002). Particular findings must be made as to the reason the skilled artisan, *with no knowledge of the claimed invention*, would have selected the components for combination in the manner claimed. See, *In re Kotzab*, 55 USPQ2d 1313, 1317 (Fed. Cir. 2000). The factual question of motivation is material to patentability and cannot be resolved on subjective belief and unknown authority. *In re Lee* at 1434. The Examiner is obliged to develop an evidentiary basis for supporting rejections. Deficiencies in the cited references cannot be remedied by conclusory statements. See, *In re Zurko*, 59 USPQ2d 1693, 1697 (Fed. Cir. 2001).

I. REJECTION UNDER 35 U.S.C. §102(b) OVER EU '480

A. Claims 1, 8 and 14

EU '480 is directed to an exhaust gas silencer-purifier, especially for internal combustion engines.

EU '480 fails to disclose the features of paragraphs (b) and (c) of Claim 1.

Paragraph (b) of Claim 1 recites "an axial fan positioned upstream of the at least one catalyst bed and having a rotatable impeller for moving the gas stream through the gas phase reactor" (emphasis added). The fan system 100 includes a drive motor 121 (Fig. 1) enclosed within a motor housing 122 (Fig. 2) and a rotatable drive shaft 125 for transmitting rotary motion to an impeller assembly 130. Specification, page 8, lines 8-11. In other words, the fan in Appellants claimed system moves the exhaust gas. In contrast to this, the fan of the EU '480 device has no motor. Rather, it is the exhaust gas which moves the fan. In the English translation of EU '480, attached hereto as Exhibit 1, at page 2, bottom paragraph it is stated (emphasis added):

> Due to these characteristics, the exhaust gases to be cleaned, generally coming from an internal combustion engine, which are routed toward said first intake, actuate the fan, giving rise to suction of additional air through said second intake, and the two streams arrive at the afterburning chamber radially stratified with exterior layers formed mainly by fresh air and interior layers formed mainly by hot exhaust gases.

Two points should be noted. First, the interaction between the moving gases and the fan in EU '480 is not the same as that claimed by Appellants. In the instant Claim 1, the fan moves the gases. In EU '480, the exhaust gases move the fan.

Second, there is a stratification of gases in the EU '480 device. Thus, EU '480 does not achieve gas flow uniformity as does Appellants' claimed device.

More particularly, nowhere does EU '480 teach a system for catalytically treating a gas stream which comprises gas flow modification means positioned between the impeller and the gas phase reactor for decreasing gas stream velocity and increasing gas flow uniformity, as recited in (c) of Claim 1.

In paragraph 1 of the final Office Action, the Examiner identifies gas flow modification means with "the flare portion 34 connected after the constricted area 13" positioned between the impeller and the gas phase reactor for decreasing gas stream velocity and increasing gas flow uniformity.

Paragraph (c) of Appellants' Claim 1 is in the 'means plus function' format. The Court of Appeals for the Federal Circuit, in its *en banc* decision *In re Donaldson Co.*, 16 F.3d 1189, 29 USPQ2d 1845 (Fed. Cir. 1994), decided that a "means or step plus function" limitation should be interpreted in accordance with 35 U.S.C. §112, sixth paragraph.[1] That is, when determining the patentability of claims under 35 U.S.C. §102 or §103, the Examiner may not disregard the structure disclosed in the specification corresponding to such language when rendering a patentability determination. See, MPEP 2181.

Referring now to Appellants' specification, pages 12-14, the gas flow modification means includes a generally cylindrical longitudinally extending tail cone 140 having a distally pointing tapered end portion 141 with a generally conical shape. Specification, page 12, lines 9-13, Fig. 2. Moreover, the housing has a distal end section 111 which flares outward in diameter such that the exit diameter of the housing is greater than the diameter at the impeller. The combined

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[1] 35 U.S.C. §112, sixth paragraph states:

> An element in a claim for combination may be expressed as a means or step for performing a specified function without the recital of structure, materials, or acts in support thereof, and such claims shall be construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof.

reduction of the diameter of the tail cone at tapered end 141 and increasing diameter of the housing at flared section 111 forms an annular diffuser which increases the cross sectional area available for gas flow and thereby reduces the velocity of the gas and tends to flatten the velocity profile of the gas. Specification, page 12, line 21 to page 13, line 9.

Additional gas flow modification features of the invention include a guide vane unit 310 and transition duct 320, which includes outwardly flared perforated walls 321. The perforations serve to prevent flow separation and improve flow uniformity. Specification, page 13 lines 10 to page 14, line 13. As noted at page 14, lines 19-23, the gas flow modification is achieved by expanding the cross-sectional area available to gas flow and the use of guide vanes, baffles and other such surfaces for orienting the flow direction of gas.

EU '480 does not disclose or suggest anything equivalent to the gas flow modification means claimed and described by Appellants. EU '480 does not discuss the desirability of decreasing the gas stream velocity and increasing the gas flow uniformity. The EU '480 exhaust gas silencer does not perform the same function as the gas flow modification means of Claim 1 (i.e., it does not decrease gas stream velocity and increase gas flow uniformity), nor does the EU '480 system perform in the same way and achieve the same result as Appellants' gas flow modification means. To the contrary, the EU '480 device includes a convergent section 13 which increases gas flow velocity, and an afterburner 15 positioned in the path of the gas stream. Moreover, the cross-sectional area available to gas flow at the catalyst elements 20, 21 is no greater than the cross-sectional area available for gas flow at the impeller 7. Nowhere in EU '480 is it disclosed that the gas flow velocity actually decreases. Nor is there any feature of the EU '480 device which would lead one skilled in the art to draw such a conclusion. Accordingly, one skilled in the art would not find any equivalent to Appellants' gas flow modification means in EU '480. Claims 8 and 14 depend from Claim 1 and are submitted to be likewise patentable over the cited reference. Reversal by the Board of the rejection of Claims 1, 8 and 14 is respectfully requested.

B. Claims 2 and 3

Claims 2 and 3 depend from Claim 1 and are submitted to be separately patentable.

Claim 2 recites that the uniformity of the gas flow is such that the gas stream entering the gas phase reactor has a velocity profile exhibiting not more than about 10% velocity deviation from an average gas stream velocity at the upstream end of the catalyst bed(s). As noted in the

specification at page 11, line 23 to page 12, line 2, the average velocity is defined by the total volumetric flow divided by the cross-sectional area available for flow.

Claim 3 further limits the velocity profile to a maximum velocity deviation of 5%.

Nowhere does EU '480 disclose or suggest any such feature. Instead, the Office Action states that EU '480 *inherently* provides a gas stream entering the gas phase reactor with a velocity profile exhibiting not more than about 10% or 5% velocity deviation from an average gas stream velocity at the upstream end of the catalyst bed. A finding of inherency requires that a publication necessarily and inevitably discloses allegedly inherent subject matter. *Trintec Industries Inc. v. Top-U.S.A. Corp.*, 295 F.3d 1292, 1295, 63 USPQ2d 1597, 1599 (Fed. Cir. 2002) ("Inherent anticipation requires that the missing descriptive material is 'necessarily present', not merely probably or possibly present, in the prior art") (quoting *In re Robertson*, 169 F.3d 743, 745, 49 USPQ2d 1946, 1950-51 (Fed. Cir. 1999)); *Glaxo, Inc. v. Novopharm Ltd.*, 830 F.Supp. 871, 874, 29 USPQ2d 1126, 1128 (E.D.N.C. 1993) ("In order for a claim to be inherent in the prior art, it is not sufficient that a person following the disclosure sometimes obtain the result set forth in the claim, it must invariably happen.") (citing *Standard Oil v. Montedison*, 664 F.2d 356, 372, 212 USPQ 327 (3rd Cir. 1981), *aff'd*, 52 F.3d 1043, 34 USPQ2d 1565 (Fed. Cir. 1995), *cert. den.* 516 U.S. 988 (1995)); *Kropa v. Robie*, 187 F.2d 150, 154-55, 88 USPQ 478, 483 (CCPA 1951) ("...Inherency does not mean that a thing might happen, one out of twenty times....It must inevitably happen for the doctrine to apply.") (citations omitted); *Hansgirg v. Kemmer*, 102 F.2d 212, 214, 40 USPQ 665, 667 (CCPA 1939) ("[An applicant] may disclose the invention by drawings, by the use of language, or he may disclose it by reciting and teaching such subject matter as will inherently do the thing or possess the quality which is claimed for it. Inherency, however, may not be established by probabilities or possibilities. The mere fact that a certain thing *may* result from a given set of circumstances is not sufficient. If, however, the disclosure is sufficient to show that the natural result flowing from the operation as taught would result in the performance of the questioned function, it seems to be well settled that the disclosure should be regarded as sufficient.") (citations omitted; emphasis in original) (quoted with approval in *In re Oelrich*, 666 F.2d 578, 581, 212 USPQ 323, 326 (CCPA 1981). Nowhere does the Examiner explain how the gas flow modification means "flow portion 34 following the constricted area" inherently provides the velocity profile claimed by Appellants. The Office Action refers to MPEP 2114 to support the statement that "apparatus claims cover what a device

is, not what a device does". Citing *Ex parte Masham*, 2 USPQ2d 1647 (Bd. Pat. App. & Inter. 1987), MPEP 2114 states in part:

> A claim containing a "recitation with respect to the manner in which a claimed apparatus is intended to be employed does not differentiate the claimed apparatus from a prior art apparatus" *if the prior art apparatus teaches all the structural limitations of the claim.* (emphasis added)

In the present instance, EU '480 does *not* teach all the structural limitations for the reasons stated above in Section I-A of this Brief.

The Office Action also presents the argument at page 18 that a velocity profile deviation of not more than 10% or 5% would be provided through routine optimization. First, absent the impermissible use of Appellants' own disclosure, there is no motivation provided by the cited reference to provide a device capable of reducing the deviation of velocity profile to said levels. Secondly, that it is possible to achieve such low levels of deviation in a device such as that in EU '480 is unsupported conjecture on the part of the Examiner.

Accordingly, reversal by the Board of the rejections of Claims 2 and 3 is respectfully requested.

C. Claim 15

Claim 15 depends from Claim 14 and is submitted to be separately patentable. Claim 15 recites that each blade unit attached to and extending radially outward from a circumferential periphery of the impeller comprises *two* blades. The claimed twin blade units are described at page 9, lines 5 to 14 of the specification and are illustrated at Fig. 4 of the drawings. EU '480 does *not* disclose or suggest a plurality of Appellants' two-blade units or any equivalent thereof. The impeller of fan 7 of the EU '480 device includes a plurality of radially extending *single* blades. Accordingly, there is no support for this rejection. Reversal of the rejection of Claim 15 by the Board is respectfully requested.

II. REJECTION UNDER 35 U.S.C. §102(b) OVER YAMAGUCHI

A. Claim 1

Yamaguchi is directed to an exhaust gas NOx removal system using a catalytic reduction process. Nowhere does Yamaguchi teach a system for catalytically treating a gas stream which comprises "gas flow modification means positioned between the impeller and the gas phase

reactor for decreasing gas stream velocity and increasing gas flow uniformity" as recited in (c) of Claim 1.

In paragraph 2 of the final Office Action, it is stated:

> Note, the convection section 4 has a front conical transition duct which constitutes the gas flow modification means for decreasing the gas velocity.

Yamaguchi defines item 4 as a flue. Col. 1, lines 21, 31, 37, 45, etc. There is no mention in the specification of Yamaguchi of a conical transition duct or any gas flow modification means. Neither is there anything in the drawings of Yamaguchi which shows gas flow modification means. It should be noted that the Yamaguchi drawings are schematic system diagrams and one cannot infer from any of the depicted units in the system that a "conical transition duct" is represented.

As stated above in Section I-A of this Brief, the "means plus function" format of paragraph (c) of Claim 1 requires that it be interpreted in accordance with 35 U.S.C. §112, sixth paragraph. There is no equivalent to Appellants' invention of Claim 1 in Yamaguchi. No feature in Yamaguchi is disclosed as decreasing gas flow velocity *and* increasing gas flow uniformity.

Accordingly, Yamaguchi does not disclose or suggest all of the features of Claim 1 and does not support this rejection. Reversal of this rejection by the Board is respectfully requested.

B. Claims 21-23, 31, 34 and 38

Claims 21-23, 31, 34 and 38 are separately patentable.

Claim 21 recites "means for recycling a portion of the flue gas from downstream of the axial fan to a convection section of the furnace located upstream of the axial fan". This recitation is in the form of "means plus function" and the comments above in Section I-A of this Brief relating to the examination of "means plus function" claims are incorporated by reference herein.

Yamaguchi does not disclose or suggest anything equivalent to the claimed feature. Rather, Yamaguchi discloses that a portion of the exhaust gas may be recycled into the NOx removal system 6 that is located downstream of flue 4, which is located downstream of turbine assembly 1. See, Fig. 2 of Yamaguchi.

The Office Action states at paragraph 2:

> With respect to the recycling portion of the flue gas upstream of the axial fan, such configuration in view of Yamaguchi to one skilled in the art appears to be an obvious matter of rearrangement of parts, since recycling a portion of the flue

> gas upstream of the axial fan or downstream of the axial fan will provide the system with the same gas treatment.

Firstly, it should be noted that the present rejection under 35 U.S.C. §102(b) is one of anticipation, not obviousness, as argued by the Examiner.

Secondly, the recycling system of the claimed invention and that of Yamaguchi do *not* provide the same gas treatment, as asserted by the Examiner. As noted in Appellants' specification at page 15, lines 13-16:

> The recycling of the flue gas helps to reduce fluctuations in the ammonia content of the flue gas entering the catalyst bed by more thoroughly distributing the ammonia.

Referring to Fig. 1 of Appellants' drawings, a portion of the flue gas containing NOx is drawn off from the transition section 300 by pipe branches 331. Ammonia is introduced into the system at inlet 338 and the NOx-containing recycled flue gas mixed with ammonia is recycled back into the convection section 20 of the furnace, which is *upstream* of the fan system 100. Thus, very intimate mixing of the NOx-containing gas and ammonia is achieved *before* entry into the catalyst beds. A uniformity of ammonia concentration is achieved such that deviations in the concentration of ammonia in the flue gas entering the catalyst bed(s) does not exceed 10%. Specification page 15, lines 16-20.

The recycling system illustrated in Fig. 2 of Yamaguchi and described at col.1, lines 35-47, recycles NOx-free gas from downstream of the catalyst beds, adds ammonia in vaporizer 11 and cycles ammonia-containing gas via line 12 to a region upstream of the catalyst but *downstream* of the turbine 1. The cycling system described in Yamaguchi is not similar to that of Appellants', nor is it equivalent in operation or result.

Moreover, there is no furnace or convection section in Yamaguchi upstream of turbine 1 to which one can recycle any exhaust gas. Fuel 2 and air 3 are introduced into the Yamaguchi turbine 1, not exhaust gas from the convection section of a furnace. The exhaust gas is generated by the gas turbine 1, not passed through it. Thus, the Yamaguchi system is not similar to that of Appellants'.

In summary, it is not a matter of obvious design choice to alter the recycle stream of Yamaguchi to discharge upstream of the gas turbine, there is no motivation provided in the Yamaguchi reference to do so, and even if it were done, it would not provide the system with the same gas treatment as that of Appellants' claimed system.

Accordingly, Yamaguchi does not support a finding of anticipation. Reversal of the rejection by the Board is respectfully requested.

C. Claim 35

Claim 35 depends from Claim 34 and is separately patentable. Claim 35 recites that each blade unit attached to and extending radically outward from a circumferential periphery of the impeller comprises *two* blades. Yamaguchi does *not* disclose any such feature or equivalent thereof. The argument presented above in Section I-C of this Brief in connection with the rejection of Claim 15 over EU '480 is incorporated by reference herein. Reversal of this rejection of Claim 35 by the Board is respectfully requested.

III. REJECTION UNDER 35 U.S.C. §103(a) OVER EU '480

A. Claims 2 and 3

Claims 2 and 3 depend from Claim 1 which is submitted to be patentable for the reasons stated above.

EU '480 does not disclose or suggest the features described in Claims 2 and 3. The Office Action states at paragraph 3:

> It appears EU '480 provide a gas flow modification means with the gas stream entering the gas phase reactor has a velocity profile exhibiting not more than 10% or 5% velocity deviation from an average gas stream velocity at the upstream end of the at least one catalyst bed.

There is no support in EU '480 for this allegation nor has the Examiner provided any foundation for this statement. The Office Action refers to MPEP 2114 to support the statement that "apparatus claims cover what a device is, not what a device does". As noted in Section I-B of this Brief, the comments of which are incorporated by reference herein, the prior art apparatus is required to teach all the structural limitations in the claim. EU '480 does not teach or suggest all of the structural limitations of the claims for the reasons stated above in Section I-A of this Brief. Accordingly, reversal by the Board of the rejection of Claims 2 and 3 is respectfully requested.

IV. REJECTION UNDER 35 U.S.C. §103(a) OVER EU '480 IN VIEW OF SURETTE

A. Claim 4

Claim 4 depends from Claim 1 which is submitted to be patentable for the reasons stated above. Claim 4 is likewise submitted to be patentable.

Moreover, Surette does not cure any of the deficiencies of EU '480 noted above. Surette discloses a stationary gas turbine power system and related method which includes a bell shaped wall 119, diffuser 115, and transition duct 109, for channeling the exhaust from turbine engine 101 into a heat recovery steam generator 23. A conical nozzle 117 creates a jet pumping action which draws air into the exhaust gas stream from closed chamber 123. The Office Action argues that it would be obvious to modify the turbine structure of EU '480 with the gas turbine with tail cone as taught by Surette.

Absent the impermissible use of Appellants' own disclosure, there is no reason why one skilled in the art, upon reading EU '480 and Surette, would be motivated to combine the nozzle 117 and diffuser 115 of the Surette gas turbine system with the exhaust gas purifier for internal combustion engines of EU '480. The Surette device is directed to relatively large stationary installations for power plants, whereas the EU '480 device is intended to be mounted to a motor vehicle to purify engine exhaust gas.

Accordingly, Claim 4 is submitted to be patentable over the EU '480 and Surette references. Reversal of the rejection of Claim 4 by the Board is respectfully requested.

V. REJECTION UNDER 35 U.S.C. §103(a) OVER EU' 480 AND SURETTE AND FURTHER IN VIEW OF TYLER ET AL. AND ISHIKAWA ET AL.

A. Claims 5, 50, 51 and 53

Tyler et al. is directed to a ground exhaust noise suppressor, especially for aircraft or other type of jet engine wakes. Tyler et al. discloses the use of a chamber 36 having perforations 48 to allow the passage of exhaust gas therethrough.

The purpose of the perforated chamber is to allow the passage of exhaust gas through perforations 48 so as to alter the noise spectrum to higher, less audible frequencies of sound. See, col. 4, lines 53-75.

As noted in the Office Action, neither EU '480 nor Surette disclose a transition duct having perforated walls. The Office Action states at paragraph 5:

> Thus, it would have been obvious in view of Tyler '846 to one having skill in the art to modify the transition duct of the applied references having perforated walls as taught by Tyler '846 in order to reduce the noise generated by the exhaust gas.

However, the transition duct of the present invention is not directed to noise reduction. Rather, perforated walls 321 serve to permit boundary layer suction, thereby preventing flow separation and increasing diffuser efficiency and flow uniformity. The boundary layer fluid is withdrawn through the perforations in the wall and ultimately drawn into a recycle manifold 330. Neither is noise reduction contemplated by Surette. The EU '480 device employs an acoustically insulated outer casing to suppress noise. However, Tyler et al. does not employ acoustic insulation to reduce noise, but rather shifts the frequency of the sound from audible low frequency noise to high frequency inaudible sound. Substituting the perforated chamber 30 of Tyler et al. with the outer casing of EU '480 would permit the engine exhaust gas to escape rather than flow through the device for purification. This would negate the intended function of the EU '480 device. Accordingly, there is no motivation provided by any of the cited patents to combine the teachings of Tyler et al. with those of EU '480 and/or Surette. Reversal of the rejection of Claims 5, 50, 51 and 53 by the Board is respectfully requested.

B. Claims 54 and 55

Claims 54 and 55 recite a guide vane with louvers for redirecting the flow of gas. These claims are separately patentable.

Neither EU '480, Surette, nor Tyler et al. disclose a guide vane unit. Ishikawa et al. is cited for disclosing a flow controller with grid vanes 3. There is no suggestion in any of the cited

references to combine the use of the guide vanes of Ishikawa with a perforated transition duct in an exhaust gas purifier such as that of EU '480. The motivation for making any such combustion comes from Appellants' own disclosure. Moreover, Claim 55 requires that the guide vanes be positioned at the inlet of the transition duct. Ishikawa discloses flow controller 3 with a grid vane at the outlet of duct 1. Moreover, Claims 54 and 55 depend ultimately from Claim 1, which is submitted to be allowable for the reasons stated above. Accordingly, Claims 54 and 55 are also submitted to be allowable. Reversal of the rejection of Claims 54 and 55 by the Board is respectfully requested.

VI. REJECTION UNDER 35 U.S.C. §103(a) OVER EU '480 IN VIEW OF TYLER ET AL. AND ISHIKAWA ET AL.

A. Claim 6

Claim 6 recites, *inter alia*, a transition duct having perforated walls which flare outwardly to gradually increase cross-sectional area available to gas stream flow.

EU '480 does not show a transition duct which has perforated walls, and does not show walls which flare outwardly to gradually increase cross-sectional area available to gas stream flow. EU '480 instead shows a convergent area 13 downstream of blades 11 which restricts the cross-sectional area available to gas flow. Moreover, burner 15 is positioned in the gas flow path downstream of the convergent section 13. EU '480 states (in translation, page 5, second paragraph):

> Starting from blades 11, the internal wall of the casing of the device forms a convergent section 13 which connects the general intake section of the device to the smaller section of passage available in afterburning chamber 14 around burner 15. (emphasis added.)

It is clear, then, that EU '480 does not disclose or suggest the invention of Claim 6. Nor does Tyler et al. or Ishikawa et al. cure the deficiencies of EU '480. Tyler et al. is directed to a ground exhaust noise suppressor. Tyler et al. discloses a perforated cylinder 36 with a conically converging rear section 38 (See, col. 4, lines 43-48). Tyler et al. does not disclose or suggest outwardly flared perforated walls as contemplated in Claim 6.

Moreover, the perforations of the Tyler et al. device are for noise suppression and not for the purposes contemplated by Appellants. See, e.g., the comments above in Section V-A of this Brief, which are incorporated by reference herein.

Ishikawa et al. does not disclose or suggest anything remotely suggestive of the transition duct of the present invention as claimed in Claim 6.

Moreover, Claim 6 depends from Claim 1 which is submitted to be patentable for the reasons stated above. Therefore, Claim 6 is also patentable. Accordingly, Claim 6 is submitted to be allowable over the cited prior art. Reversal of the rejection of Claim 6 by the Board is respectfully requested.

B. Claim 56

Claim 56 depends from Claim 6 and further recites, *inter alia*, a guide vane unit with louvers for redirecting the flow of gas and is submitted to be separately patentable.

Neither EU '480 nor Tyler et al. disclose a guide vane unit. Ishikawa et al. discloses a denitration reactor having a flow controller 3 of a grid vane type. Ishikawa et al. does not disclose or suggest a transition section with outwardly flared perforated walls. Nor does Ishikawa et al. disclose or suggest positioning guide the vanes at the inlet of a transition duct. As noted above, Ishikawa et al. discloses a grid vane unit 3 at the outlet of duct 1, which does not have the features of Appellants' claimed transition duct.

Accordingly, the cited references, whether taken individually or in combination, do not disclose or suggest Appellants' claimed invention.

Reversal of the rejection of Claim 56 by the Board is respectfully requested.

VII. REJECTION UNDER 35 U.S.C. §103(a) OVER EU '480 IN VIEW OF YAMAGUCHI

A. Claims 7 and 18-20

Claims 7 and 18-20 include the feature of recycling a portion of the gas stream from downstream of the axial fan to a position upstream of the axial fan. Referring to Fig. 1 of Appellants' drawings and page 15, lines 1-20, it can be seen that flue gas from the chamber portion 303 is drawn through branches 331 of the recycle manifold 330 and directed into the convection section 20 of the furnace. Thus, a portion of the gas stream is recycled from downstream of the axial fan 130 to a position upstream of the axial fan. The Office Action argues that such an arrangement is disclosed by Yamaguchi:

> Yamaguchi '355 teaches a portion of the NOx-free exhaust gas is recirculated back to a position upstream of the axial fan (best understood by Examiner to be the front back of the catalyst system to facilitate vaporizing the aqueous ammonia prior to injecting to the catalyst layer of the NOx removal system.

However, the input and exhaust of the recycling system of Yamaguchi are both downstream of the gas turbine 1. See Fig. 2 of Yamaguchi. What Yamaguchi appears to disclose is the recycling of gas from downstream of the catalyst system 6 to a position upstream of the catalyst system 6. Yamaguchi does not disclose recycling gas from downstream of the axial fan to a position upstream of the axial fan.

Moreover, unlike Appellants' claimed system, Yamaguchi does not employ the gas turbine to move exhaust gas from the convection section of a furnace to a catalytic system for removing NOx. Rather, fuel 2 and oxygen 3 are combusted in gas turbine 1 of Yamaguchi and generate exhaust gas. There is no suggestion in Yamaguchi to recycle any exhaust gas upstream of the gas turbine.

Accordingly, none of the cited references, taken individually or in combination, disclose or suggest the invention claimed by Appellants herein. Reversal of the rejection of Claims 7 and 18-20 by the Board is respectfully requested.

VIII. REJECTION UNDER 35 U.S.C. §103(a) OVER EU '480 IN VIEW OF BALLING ET AL.

A. Claims 9, 10, 12 and 13

Claims 9, 10, 12 and 13 depend directly or indirectly from Claim 1, which is submitted to be patentable for at least the reasons stated above in sections I and II of this Brief. Accordingly, Claims 9, 10, 12 and 13 are also submitted to be patentable.

Moreover, EU '480 is directed to an exhaust gas purifier for internal combustion engines whereas Balling et al. is directed to a catalytic converter for removing nitrogen oxides from a flue gas (e.g., in a selective catalytic reduction process). Internal combustion engine exhaust gases produced by combusted gasoline or other motor fuels would not be expected to have the same composition as the flue gases contemplated by Balling et al. Accordingly, one skilled in the art would not expect the catalysts to be interchangeable. For example, EU '480 employs a catalyst of permeable sintered material of hollow spheroidal globules of copper or copper alloy. EU '480, page 5 lines 19-23. There is no suggestion in the cited references for their combination. Accordingly, reversal of this rejection by the Board is respectfully requested.

IX. REJECTION UNDER 35 U.S.C. §103(a) OVER EU '480 IN VIEW OF CARLBORG ET AL.

A. Claim 11

Claim 11 depends from Claim 1, which is submitted to be patentable for at least the reasons stated above in Sections I and II of this Brief. Accordingly, Claim 11 is also submitted to be patentable.

Moreover, there is no motivation provided in either of these references for one skilled in the art to make the combination suggested by the Examiner. EU'480 teaches that the catalyst for the exhaust gas purifier for internal combustion engines has good filtration properties and acts as a filtering agent. EU '480, page 5, lines23-27. There is no disclosure in Carlbourg et al. that the mesh like structure with 85% porosity performs a filtration function. Accordingly, there is no suggestion to combine these references. Reversal of this rejection by the Board is respectfully requested.

X. REJECTION UNDER 35 U.S.C. §103(a) OVER EU '480 IN VIEW OF PRIOR ART ADMISSION

A. Claim 16

Claim 16 depends indirectly from Claim 1, which is submitted to be patentable for at least the reasons stated above in sections I and II of the Brief. Accordingly, Claim 16 is also submitted to be patentable.

Moreover, there is no suggestion in EU '480 or the Admission for incorporating a variable pitch propeller into fan 7 of EU '480. As noted above, it is the exhaust gases which move the fan 7 of the EU '480 device, whereas the impeller of Appellants' system are motorized and move the flue gases. The statement in the Office Action that it would be obvious to modify the fan blade of EU '480 with blades of variable pitch in order to control the flue velocity is not correct. The EU '480 fan 7 does not control the flue gas velocity. Rather, the flue gas velocity controls the fan 7. One skilled in the art would find no reason to combine the features of the present claimed invention with the EU '480 device. Accordingly, reversal of this rejection by the Board is respectfully requested.

XI. REJECTION UNDER 35 U.S.C. §103(a) OVER EU '480 IN VIEW OF ACASTER

A. Claim 17

Claim 17 depends indirectly from Claim 1, which is submitted to be patentable for at least the reasons stated above in sections I and II of this Brief. Accordingly, Claim 17 is also submitted to be patentable.

As noted above, the fan 7 of EU '480 does not move the exhaust gas, but is rather moved by the exhaust gas. Accordingly, one skilled in the art would not be motivated to modify the fan of EU '480 with a variable speed impeller "in order to keep up with the demand of the exhaust gas and pressure," as suggested in the Office Action. Reversal of this rejection by the Board is respectfully requested.

XII. REJECTION UNDER 35 U.S.C. §103(a) OVER EU '480 IN VIEW OF YAMAGUCHI

A. Claims 21-24

Independent Claim 21 recites, *inter alia*, means for recycling a portion of the flue gas from downstream of the axial fan to a convection section of the furnace located upstream of the axial fan. Claims 22 to 24 depend directly or indirectly from Claim 21 and therefore also incorporate this recitation.

Neither EU '480 nor Yamaguchi disclose or suggest this feature. These issues are discussed above in Section VII of this Brief, the comments therein being incorporated by reference herein. Accordingly, Claims 21 to 24 are submitted to be patentable over the cited references. Reversal of this rejection by the Board is respectfully requested.

XIII. REJECTION UNDER 35 U.S.C. §103(a) OVER EU '480 IN VIEW OF YAMAGUCHI AS APPLIED TO CLAIM 22 AND FURTHER IN VIEW OF TYLER ET AL. AND ISHIKAWA ET AL.

A. Claim 25

EU '480 does not show a transition duct which has perforated walls, and does not show walls which flare outwardly to gradually increase cross-sectional area available to gas stream flow. EU '480 instead shows a convergent area 13 downstream of blades 11 which restricts the cross-sectional area available to gas flow. Moreover, burner 15 is positioned in the gas flow path downstream of the convergent section 13. EU '480 states (in translation, page 5, second paragraph):

> Starting from blades 11, the internal wall of the casing of the device forms a convergent section 13 which connects the general intake section of the device to the smaller section of passage available in afterburning chamber 14 around burner 15. (emphasis added.)

It is clear, then, that EU '480 does not disclose or suggest the invention of Claim 25. Nor does Yamaguchi or Tyler et al. or Ishikawa et al. cure the deficiencies of EU '480. Tyler et al. is directed to a ground exhaust noise suppressor. Tyler et al. discloses a perforated cylinder 36 with a conically converging rear section 38 (See, col. 4, lines 43-48). Tyler et al. does not disclose or suggest outwardly flared perforated walls as contemplated in Claim 25.

Moreover, the perforations of the Tyler et al. device are for noise suppression and not for the purposes contemplated by Appellants. See, e.g., the comments above in Section V-A of this Brief, which are incorporated by reference herein.

Ishikawa et al. does not disclose or suggest anything remotely suggestive of the transition duct of the present invention as claimed in Claim 25.

Moreover, Claim 25 depends from Claim 21 which is submitted to be patentable for the reasons stated above. Therefore, Claim 25 is also patentable. Accordingly, Claim 25 is submitted to be allowable over the cited prior art. Reversal of the rejection of Claim 25 by the Board is respectfully requested.

B. Claim 26

Claim 26 depends from Claim 25 and further recites a gas stream manifold having at least one inlet connected to the transition duct and at least one outlet connected to the convection section of the furnace. Claim 26 is submitted to be separately patentable.

None of the cited references disclose such a feature. At paragraph 13, the Office Action states:

> Regarding Claim 26, Yamaguchi shows on Fig. 2 the gas stream recycle manifold has at least one inlet connected to the transition duct and at least one outlet connected to the convection section of the furnace.

This characterization of Yamaguchi Fig. 2 is not correct. The inlet of the recycle stream is located downstream of the NOx removal system, not in anything equivalent to a transition duct as contemplated by Appellants. (See Claim 26.) The exhaust gas recycle outlet of Yamaguchi is not connected to a convection section of any furnace. Rather, the exhaust gas is first sent to an ammonia vaporizer 11 and the mixture of ammonia and exhaust gas is discharged downstream of the turbine 1 and upstream of the nitrogen removal system 6. Yamaguchi does not disclose a

furnace having a convection section. Unlike Appellant's system, the gas turbine 1 of Yamaguchi does not move exhaust gas from a furnace, but rather is a means by which fuel 2 and air 3 are combusted to generate exhaust gas. The Yamaguchi system does not relate to the removal of NOx from the flue gas of a furnace. Therefore, there is no disclosure or suggestion to provide a recycle manifold outlet in the convection section of a furnace.

Accordingly, none of the cited references, whether taken individually or in combination, disclose or suggest the invention of Claim 26. Reversal of the rejection by the Board is respectfully requested.

XIV. REJECTION UNDER 35 U.S.C. §103(a) OVER YAMAGUCHI IN VIEW OF TYLER ET AL. AND ISHIKAWA ET AL.

A. Claim 25

The comments above in Section XIII-A of this Brief are reiterated herein with full force and effect.

More particularly, the Office Action states that Yamaguchi discloses a transition duct (4) which flares out to gradually increase cross-sectional area. This statement is unsupported by the Yamaguchi reference. Yamaguchi does not anywhere describe or show a transition duct. Item (4) cited by the Examiner as being the "transition duct" is described by Yamaguchi as a flue. (Col. 3, lines 27, 32, 43, and 52, for example). One cannot infer from the drawings of Yamaguchi that there is any transition duct which flares out gradually to increase cross-sectional area because the drawings are schematic and nothing in the Yamaguchi specification supports such an inference.

Tyler et al. is cited for disclosing perforated walls. The Office Action states:

> Thus, it would have been obvious in view of Tyler '846 to one having ordinary skill in the art to modify the transition duct of Yamaguchi having perforated walls as taught by Tyler '846 in order to reduce noise generated from the exhaust gas.

Firstly, as stated above, Yamaguchi does not disclose or suggest a transition duct as contemplated by Appellants. Secondly, Tyler et al. does not disclose perforated flared walls. Thirdly, the purpose of the Tyler et al. device is to suppress the noise of aircraft yet engine exhaust, which has no relation to the purpose of the perforated walls of Appellants' transition duct, as explained above in Section V-A of this Brief.

Ishikawa et al. does not cure the deficiencies of Yamaguchi and Tyler et al. The Office Action cites Ishikawa et al. for teaching a flow controller 3 in front of a catalyst layer 4. However, the flow controller 3 of Ishikawa et al. is a grid vane which is not a component of a perforated wall which flares outward so as to gradually increase cross-sectional area available to flue gas flow, which is a feature of Claim 25 which the Examiner fails to consider.

Accordingly, there is no suggestion in any of the cited references to support the combination of their teachings, and even if they were to be combined, the features of Appellants' claimed invention would not be disclosed or suggested.

Reversal of this rejection by the Board is respectfully requested.

B. Claim 26

Separately patentable Claim 26 depends from Claim 25 and further recites a gas stream recycle manifold having at least one inlet connected to the transition duct and at least one outlet connected to the convection section of the furnace.

As explained above, Yamaguchi does not disclose or suggest such a feature. The comments above in connection with Section XIII-B of this Brief are incorporated herein with full force and effect.

Reversal of this rejection by the Board is respectfully requested.

XV. REJECTION UNDER 35 U.S.C. §103(a) OVER YAMAGUCHI IN VIEW OF SURETTE

A. Claim 27

Claim 27 depends from independent Claim 21, which is submitted to be patentable for at least the reasons stated above in Section XII-A of this Brief, the comments of which are incorporated herein with full force and effect. Accordingly, Claim 27 is also submitted to be patentable. Reversal of this rejection by the Board is respectfully requested.

XVI. REJECTION UNDER 35 U.S.C. §103(a) OVER YAMAGUCHI IN VIEW OF CARLBORG ET AL.

A. Claim 30

Claim 30 depends from independent Claim 21 which is submitted to be patentable for at least the reasons stated above in Section XII-A of the Brief, the comments of which re incorporated herein with full force and effect. Accordingly, Claim 30 is also submitted to be patentable.

Reversal of this rejection by the Board is respectfully requested.

XVII. REJECTION UNDER 35 U.S.C. §103(a) OVER YAMAGUCHI IN VIEW OF BALLING ET AL.

A. Claims 28-29 and 32-33

These claims depend directly or indirectly from independent Claim 21, which is submitted to be patentable for at least the reasons stated above in Section XII-A of this Brief, the comments of which are incorporated herein with full force and effect. Accordingly, Claims 28, 29, 32 and 33 are submitted to be patentable. Reversal of this rejection by the Board is respectfully requested.

XVIII. REJECTION UNDER 35 U.S.C. §103(a) OVER YAMAGUCHI IN VIEW OF ADMISSION

A. Claim 36

Claim 36 depends indirectly from independent Claim 21, which is submitted to be patentable for at least the reasons stated above in Section XII-A of this Brief, the comments of

which are incorporated herein with full force and effect. Accordingly, Claim 36 is also submitted to be patentable. Reversal of this rejection by the Board is respectfully requested.

XIX. REJECTION UNDER 35 U.S.C. §103(a) OVER YAMAGUCHI IN VIEW OF ACASTER

A. Claim 37

Claim 37 depends indirectly from independent Claim 21, which is submitted to be patentable for at least the reasons stated above in Section XII-A of this Brief, the comments of which are incorporated herein with full force and effect. Accordingly, Claim 37 is also submitted to be patentable. Reversal of this rejection by the Board is respectfully requested.

XX. REJECTION UNDER 35 U.S.C. §103(a) OVER EU '480 IN VIEW OF SURETTE AND TYLER ET AL. AND ISHIKAWA ET AL. AS APPLIED TO CLAIMS 1 AND 4 ABOVE AND FURTHER IN VIEW OF ZAGOROFF ET AL.

A. Claim 52

Claim 52 depends directly or indirectly from independent Claim 1, which is submitted to be patentable for at least the reasons stated above in Sections I-A and II-A of this Brief, the comments of which are incorporated herein with full force and effect. Accordingly, Claim 52 is also submitted to be patentable. Reversal of this rejection by the Board is respectfully requested.

XXI. REJECTION UNDER 35 U.S.C. §103(a) OVER EU '480 IN VIEW OF SURETTE AS APPLIED TO CLAIM 27 AND IN FURTHER VIEW OF TYLER ET AL. AND ISHIKAWA ET AL.

A. Claim 57

None of the cited references disclose or suggest a transition duct having perforated walls that flare outward and a guide vane unit including louvers for redirecting the flow of the flue gas. EU '480 does not show perforated walls that flare outward. Surette discloses a transition duct 109 for channeling engine exhaust to a heat recovery section. However, the walls of the transition duct 109 are not disclosed as being perforated. Tyler et al. discloses a ground exhaust noise suppressor for aircraft jet engines. The walls of the noise suppressor are perforated but do not flare outward. Moreover, the stated purpose of the perforated walls is to suppress noise which is not a concern of the EU '480 or Surette patents. There is nothing in the cited references

which would motivate one skilled in the art to combine the teachings of Tyler et al. with those of EU '480 or Surette. The guide vane unit 3 of Ishikawa is not positioned at the inlet of a transition duct, as required by Claim 57, nor does Ishikawa et al. cure the defects of the EU '480, Surette and Tyler et al. references. Accordingly, none of the cited references, whether taken individually or in combination, disclose or suggest Appellants' invention as recited in Claim 57. Reversal of the rejection of Claim 57 by the Board is respectfully requested.

VIII. Claims Appendix

The claims on appeal are as follows:

1. A system for catalytically treating a gas stream, which comprises:

a) a gas phase reactor containing a catalyst for the treatment of the gas stream in at least one catalyst bed having an upstream end and a downstream end;

b) an axial fan positioned upstream of the at least one catalyst bed and having a rotatable impeller for moving the gas stream through the gas phase reactor; and,

c) gas flow modification means positioned between the impeller and the gas phase reactor for decreasing gas stream velocity and increasing gas flow uniformity.

2. The system of claim 1 wherein the gas flow uniformity is increased by the gas flow modification means such that the gas stream entering the gas phase reactor has a velocity profile exhibiting not more than about 10% velocity deviation from an average gas stream velocity at the upstream end of the at least one catalyst bed.

3. The system of claim 2 wherein the velocity profile of the gas stream exhibits no more than about a 5% velocity deviation from an average gas stream velocity at the upstream end of the at least one catalyst bed.

4. The system of claim 1 wherein the axial fan includes a housing and a tail cone, and the gas flow modification means includes a distally pointing tapered end portion of the tail cone and a flared portion of the housing having a gradually increasing diameter.

5. The system of claim 4 wherein the gas flow modification means further includes a transition duct having perforated walls which flare outward so as to gradually increase cross-sectional area available to gas stream flow.

6. The system of claim 1 wherein the gas flow modification means includes a transition duct having perforated walls which flare outward so as to gradually increase cross-sectional area available to gas stream flow.

7. The system of claim 1 further including means for recycling a portion of the gas stream from downstream of the axial fan to a position upstream of the axial fan.

8. The system of claim 1 wherein the gas stream contains nitrogen oxide.

9. The system of claim 1 wherein the catalyst bed includes a plurality of stackable, individually separable modules containing one or more materials selected from the group consisting of vanadium oxide, aluminum oxide, titanium oxide, tungsten oxide, molybdenum oxide and zeolite.

10. The system of claim 9 wherein the modules each comprise a plurality of stacked catalyst elements having a honeycomb type structure.

11. The system of claim 1 wherein the catalyst bed comprises a catalyst supported on a mesh-like structure having a void space of at least about 85%.

12. The system of claim 1 wherein the catalyst bed includes a vanadium pentoxide catalyst on titanium oxide support.

13. The system of claim 1 wherein the gas phase reactor comprises at least two catalyst beds arranged in series.

14. The system of claim 1 wherein the fan impeller includes a plurality of blade units attached to and extending radially outward from a circumferential periphery of the impeller.

15. The system of claim 14 wherein the blade units each comprise two blades.

16. The system of claim 14 wherein the blade units have a variable pitch which is controllable while the impeller is rotating.

17. The system of claim 14 wherein the impeller has a variable speed of rotation which is adjustable while the impeller is rotating.

18. The system of claim 1 further including a heat recovery section positioned downstream of the gas phase reactor for cooling the gas stream.

19. The system of claim 1 further including means for introducing reducing agent into the gas stream.

20. The system of claim 19 further including a gas stream recycle manifold for communicating a portion of the gas stream downstream of the axial fan to a convection section of a furnace positioned upstream of the axial fan, wherein the means for introducing reducing agent comprises an inlet for introducing the reducing agent into the gas stream recycle manifold.

21. A system for catalytically treating a furnace flue gas, which comprises:

a) a gas phase reactor containing a catalyst for the treatment of the flue gas in at least one catalyst bed having an upstream end and a downstream end;

b) an axial fan positioned upstream of the at least one catalyst bed and downstream of a furnace and having a rotatable impeller for moving the flue gas from the furnace through the gas phase reactor; and,

c) means for recycling a portion of the flue gas from downstream of the axial fan to a convection section of the furnace located upstream of the axial fan.

22. The system of claim 21 wherein the means for recycling a portion of the flue gas comprises a gas stream recycle manifold.

23. The system of claim 22 wherein the gas stream recycle manifold includes an inlet for introducing reducing agent into recycle manifold.

24. The system of claim 22 wherein the gas stream recycle manifold includes a control valve.

25. The system of claim 22 further comprising a transition duct having perforated walls which flare outward so as to gradually increase cross-sectional area available to flue gas flow.

26. The system of claim 25 wherein the gas stream recycle manifold has at least one inlet connected to the transition duct, and at least one outlet connected to the convection section of the furnace.

27. The system of claim 21 wherein the axial fan includes a housing and a tail cone, the housing having a flared distal portion and the tail cone having a distally pointing tapered end portion.

28. The system of claim 21 wherein the catalyst bed includes a plurality of stackable, individually separable modules containing one or more materials selected from the group consisting of vanadium oxide, aluminum oxide, titanium oxide, tungsten oxide, molybdenum oxide and zeolite.

29. The system of claim 28 wherein the modules each comprise a plurality of stacked catalyst elements having a honeycomb type structure.

30. The system of claim 21 wherein the catalyst bed comprises a catalyst supported on a mesh-like structure having a void space of at least about 85%.

31. The system of claim 21 wherein the flue gas contains nitrogen oxide.

32. The system of claim 31 wherein the at least one catalyst bed includes a vanadium pentoxide catalyst on titanium oxide support.

33. The system of claim 21 wherein the gas phase reactor comprises at least two catalyst beds arranged in series.

34. The system of claim 21 wherein the fan impeller includes a plurality of blade units attached to and extending radially outward from a circumferential periphery of the impeller.

35. The system of claim 34 wherein the blade units each comprise two blades.

36. The system of claim 34 wherein the blade units have a variable pitch which is controllable while the impeller is rotating.

37. The system of claim 34 wherein the impeller has a variable speed of rotation which is adjustable while the impeller is rotating.

38. The system of claim 21 further including a heat recovery section positioned downstream of the gas phase reactor for cooling the flue gas.

50. The system of claim 1, wherein the gas flow modification means comprises:

a housing including a tail cone, wherein the housing surrounds the axial fan, and wherein the tail cone is positioned downstream from the axial fan; and,

a transitional duct having perforated walls that are flared outward disposed downstream from the housing.

51. The system of claim 50, wherein the tail cone has a substantially conical shape and comprises a distally pointing tapered end portion.

52. The system of claim 51, wherein the tail cone is supported within the housing by longitudinally oriented planar struts positioned in an annular space between the tail cone and an interior surface of the housing, wherein the struts act as baffles to reduce swirl and direct gas flow towards an axial flow of the flue gas through the system.

53. The system of claim 50, wherein the housing further comprises:

an outlet, wherein a diameter of the outlet is greater than a diameter of an impeller of the axial fan, and wherein the circumference of the housing gradually increases from a position of the housing at the axial fan to the outlet of the housing.

54. The system of claim 50, wherein the gas flow modification means further comprises a guide vane unit disposed at an inlet of the transition duct, wherein the guide vane unit includes louvers for redirecting the flow of the flue gas.

55. The system of claim 4, wherein the gas flow modification means further comprises:

a transition duct having perforated walls that flare outward positioned downstream from the housing; and,

a guide vane unit disposed at an inlet of the transition duct, wherein the guide vane unit includes louvers for redirecting the flow of the flue gas.

56. The system of claim 6, wherein the gas flow modification means further comprises:

a transition duct having perforated walls that flare outward positioned downstream from the housing; and,

a guide vane unit disposed at an inlet of the transition duct, wherein the guide vane unit includes louvers for redirecting the flow of the flue gas.

57. The system of claim 27, wherein the gas flow modification means further comprises:

a transition duct having perforated walls that flare outward positioned downstream from the housing; and,

a guide vane unit disposed at an inlet of the transition duct, wherein the guide vane unit includes louvers for redirecting the flow of the flue gas.

IX. Evidence Appendix

None

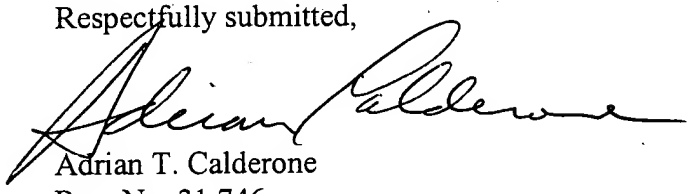
X. Related Proceedings Appendix

None

CONCLUSION

For at least the reasons stated above, all of the claims are submitted to be patentable. Reversal of all of the rejections by the Board is respectfully requested.

Respectfully submitted,



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EXHAUST MUFFLER-CLEANER, PARTICULARLY FOR INTERNAL COMBUSTION ENGINES

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EXHAUST MUFFLER-CLEANER, PARTICULARLY FOR INTERNAL COMBUSTION ENGINES

[Silencieux-epurateur d'echappement, specialement pour des moteurs a combustion interne]

Inventor:	Luigi Carboni
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The present invention relates to an exhaust muffler-cleaner, particularly for internal combustion engines, of the type in which the exhaust gases not only are regularized in their flow conditions in order to reduce noise but are also subjected to afterburning for the purpose of eliminating their unburned parts, and to catalytic action aiming to eliminate the harmful substances. /1*

It is known that the pollution produced by combustion, and particularly by that taking place inside internal combustion engines, is not due to the products of regular combustion of hydrocarbons (carbon dioxide and steam) but rather is due to the products derived from incomplete combustion (unburned hydrocarbons and carbon monoxide), to the products of combustion of impurities (particularly sulfur compounds) and to the products derived from

* [Numbers in right margin indicate pagination of the original text.]

collateral chemical reactions (among which the nitrogen oxides are particularly harmful). For these reasons, much research has been done with the aim of producing exhaust gas cleaning devices capable of eliminating said contaminating products, and particularly valuable results have been obtained in particular based on previous studies performed by the same author of the present invention, through the combination of afterburning action and catalytic action, in a device which acts simultaneously as muffler and cleaner and which is suitable moreover for providing an auxiliary thrust which is useful for propulsion. However, these devices pose certain problems with no easy productive solution, the first of which is the production of a simple and sure means of combustion, capable of initiating and maintaining the afterburning reaction in spite of the low flammability of the exhaust gas mixtures in which the unburned products to be burned are present in a very dilute state.

The difficulties encountered in cleaning exhaust gases produced by gaseous fuels or /2
gasoline are further multiplied in the cleaning of the exhaust gases produced by gas-oil or by fuel oils, particularly because of the high content of impurities contained in them. It has consequently not been possible up to now to satisfactorily clean the exhaust of Diesel engines.

The present invention aims to give a satisfactory solution to the problems posed up to now by the muffler-cleaners of the type mentioned in the preamble.

This goal is reached, according to the present invention, by the fact that the device mainly includes a first intake for the exhaust gases to be treated, a second intake with nonreturn valves for additional air, said second intake being arranged in the form of a ring around the first intake, an axial suction fan arranged so as to act with its central portion in association with said first intake, and with its peripheral portion in association with said second intake, an afterburning chamber arranged so as to receive the confluence of the flows coming from said first and second intakes, a burner arranged in said afterburning chamber, said burner being in the form of a hollow body with intake and outlet openings and containing thermal elements electrically heated to the temperature of light emission, a set of catalytic elements arranged downstream from said afterburning chamber, and a flow adaptor; as well as a thermally and acoustically insulated casing whose internal walls are aerodynamically shaped so as to follow the transformations of the gases passing through the different parts of the device.

Due to these characteristics, the exhaust gases to be cleaned, generally coming from an internal combustion engine, which are routed towards said first intake, actuate the fan, giving rise to suction of additional air through said second intake, and the two streams arrive at the afterburning chamber radially stratified, with exterior layers formed mainly by fresh air and /3
interior layers formed mainly by hot exhaust gases. A part of the latter penetrates into the burner where, because of the combined effect of thermal and light emissions of the thermal elements, an endothermic dissociation of the carbon dioxide and other compounds takes place. It has been

observed that this phenomenon is greatly promoted by the photochemical effect exerted by the incandescent thermal elements. The phenomenon, which takes place in an intense manner in the burner, is verified partially also in the surrounding medium when, under operating conditions, the whole burner reaches a temperature of light emission. The part of the exhaust gases thus treated then flows through the outlet openings of the burner, being mixed with the rest of the gases in the afterburning chamber, where the exothermic recombination of the carbon dioxide and other compounds is carried out, with a consequent increase of the temperature and an effective igniting of the unburned substances and of the carbon monoxide, which are then burned with the help of the oxygen contained in the additional air. In this way, an almost complete elimination of the unburned substances and of the carbon monoxide is obtained. The hot gases leaving the afterburning chamber then go into the set of catalytic elements, in which catalytic cracking affects the residues of the unburned substances, and the carbon monoxide is oxidized, while the nitrogen oxides and certain other substances are decomposed and reduced to noncontaminating elements. Finally, through the exhaust pipe adaptor, the gases are discharged with recovery of at least a part of their kinetic energy in the form of usable mechanical thrust.

When the device is intended for a vehicle, said second intake is advantageously arranged so as to be subjected to the action of a stagnation pressure produced by the wind from the travel of the vehicle. In this way, suction of additional air is promoted, and under particular conditions, it can be the additional air itself that actuates the fan, in that case exerting a suction action on the exhaust of the engine to which the device is applied. /4

The suction fan is calculated to exert its maximum action at medium speed (for example, at 60% of the maximum speed) of the engine for which the device is intended. This gives rise to the greatest practical yield, in consideration of the fact that the maximum speeds are only rarely used.

Preferably, said burner is in the form of a body made of stainless steel containing nickel. In this way, the catalytic properties of this metal are used to make the described effects more intense.

Moreover, said set of catalytic elements is preferably made up of a series of alternating disks and rings formed by a permeable sintered material of hollow spheroidal globules of copper or copper alloy. Catalytic elements of this type, of reasonable cost, have a long service life and join a useful filtration effect with their catalytic action. The latter, different from that of the platinum-containing catalyst ordinarily used, is not limited to action on the nitrogen oxides, but acts in particular on the sulfur compounds, giving rise to solid residues which consequently can be separated easily.

Preferably, installed downstream from the set of catalytic elements is a nondissipative noise dampening component, formed by a spiral perforated metallic sheet. Such a component

regularizes the exiting stream, attenuating its vibrations, without offering any appreciable resistance to the stream itself.

It is advantageously provided that the flow adaptor is delimited by two elements mutually fitting together, applied towards one another by elastic components, with a pressure corresponding to the action exerted by the exhaust gases under medium operating conditions. In this way, under operating conditions at speeds higher than medium speed, said two elements delimiting the flow adaptor are moved apart from one another by the pressure of the gases, and /5
they then offer a larger cross section for the flow, thus preventing choking which under these conditions is verified in the usual mufflers and which leads to a reduction of the yield.

These characteristics of the invention and others will emerge more clearly from the following description of an embodiment given as a nonlimiting example and illustrated diagrammatically in the appended drawings in which:

Figure 1 represents, on a reduced scale, a longitudinal section of an exhaust muffler-cleaner according to the present invention;

Figure 2 is a view, considered according to arrow II of Figure 1, of the second intake provided with a nonreturn valve;

Figure 3 represents a section made according to broken line III-III of Figure 1, and it shows the suction fan in particular;

Figure 4 represents a section made according to line IV-IV of Figure 1, and it shows the burner in particular;

Figure 5 is an axial view of the device on the flow side, considered according to arrow V of Figure 1.

Indicated by the number 0 in Figure 1 is a terminal section of an exhaust pipe, for example, of the endothermic engine of a vehicle, to which the muffler-cleaner device according to the invention is applied. The shape and dimensions of this device are similar to those of an ordinary exhaust muffler, and its installation consequently entails no particular problem. Section 0 of the exhaust pie is inserted and attached in tubular element 1 constituting the first intake of the device. Arranged coaxially around this first intake 1 is tubular element 2 of greater diameter, constituting the second intake intended for the passage of additional air, said second intake, if applicable, will be arranged so that it is caught by the wind from the travel of the vehicle so that a stagnation pressure can act on it. Arranged in tubular element 2 is valve plate 3 which /6
cooperates with lamellar valve segments 4 protected by curved posterior shoulders 5, in order to form a nonreturn valve allowing the suction of air but not its accidental back flow. This suction unit is protected exteriorly by shell 6 of perforated sheet metal or metallic netting.

Arranged behind the concentric openings of intake elements 1 and 2 is helical fan 7 with longitudinal axis, with five blades in the present case, whose shaft freely pivots in bearings 8 and

10. Bearing 8 is supported by radial blades 9 in the first intake element 1, and bearing 10 is supported in the center of a star arrangement of blades 11 for orientation of the flow, which are anchored peripherally to the casing of the device, which is described below. Advantageously, similar orientation blades 12 are arranged in the opening of tubular element 2, which they mechanically connect with coaxial intake element 1.

Arranged downstream from blades 11 is afterburning chamber 14, in the anterior part of which burner 15 is installed. The latter is made up of a substantially spheroidal hollow body made of stamped stainless steel sheet in the form of two shells which extend laterally in order to form blades 16 used for supporting burner 15. Starting from blades 11, the internal wall of the casing of the device forms convergent section 13 which connects the general intake section of the device to the smaller section of passage available in afterburning chamber 14 around burner 15.

Formed in the anterior part of burner 15 are openings 17, through which a part of the stream which sweeps the burner can penetrate into the latter. Mounted in the posterior part of the burner are thermal elements 18, in the present case in the form of ceramic glow plugs containing electrical resistors planned and supplied so to maintain said glow plugs at a temperature of incandescence, for example, at 600°C. The burner ends posteriorly with at least one flow /7
opening 19, through which it opens into afterburning chamber 14.

Installed at the rear end of afterburning chamber 14 is a set of catalytic elements made up of disks 20 alternating with rings 21; these parts are assembled by longitudinal bolts 22, and rings 21 are supported peripherally by the casing of the device. Disks 20 and rings 21 are preferably formed by a permeable sintered material of hollow spheroidal globules of copper or copper alloy. In this material, the ratio between the exposed surface and the volume is very high, and consequently, this material is appropriate for being used as effective catalyst, and it moreover has good filtration properties. As catalyst, it acts effectively in particular on the nitrogen and sulfur compounds, and as filtering agent, it separates the powdery residues, particularly the lead oxides and sulfur compounds.

The last disk 20 carries a noise dampening component formed by tapered casing 23 made of perforated sheet metal, in which spiral metallic leaf spring 24, also run through by perforations, is wound with its turns spaced out. This structure forms a number of communicating chambers, substantially open in the direction of the flow, which exert an effective action of attenuation of the vibrations and consequently of the noise without offering appreciable resistance to the gas flow.

The device ends with a flow opening which, in the example represented, is delimited by two channel elements 25 and 26, fitted in one another, articulated anteriorly at 27 to the casing of the device and pushed towards one another by leaf springs 28. Elements 25 and 26 can be

moved, when the force of leaf springs 28 is overcome, to a position indicated by a dotted line in Figure 1, in that case increasing the cross section of flow of the device.

Passages 29 can be provided in order to allow the ambient air to proceed to sweep /8
channel elements 25 and 26, flowing posteriorly around the flow of exhaust gases leaving these channel elements. This flow of air also acts towards a useful cooling of springs 28.

The casing of the device, which encloses all the components described up to now, is formed substantially by two stamped sheet metal shells, one lower 30 and the other upper 31, joined along a horizontal axial plane and connected to one another by rims 32. This arrangement allows very easy mounting of the whole structure, and rims 32 also ensure the connection of certain internal parts, such as blades 16 of burner 15. If considered by the way, certain parts of one of the shells can be made removable, by replacing rim sections with connections using bolts, in order to allow access to the mobile internal parts, such as fan 7 and channel elements 25 and 26, or to other parts whose replacement can be foreseen. The shells of the casing are double walled, and acoustically and thermally insulating materials 33 are arranged between the external wall and the internal wall. In the site of afterburning chamber 14, which represents a source of heat, it is possible also to provide exterior wall 34 surrounding casing 30-31 a certain distance away from it in order to guide the air to sweep the casing and to cool it effectively.

The functioning of the device which has been described is the following. The exhaust gases coming from the engine go from exhaust pipe 0 to tubular intake 1 and act on fan 7 making it turn and consequently giving rise to the suction of a stream of additional air from intake 2 through nonreturn valve 3-5. The two streams proceed together, oriented by blades 11, but at least partially separated by a stratification, with hotter layers formed mainly by exhaust gases inside, and with cooler layers formed mainly by additional air on the outside. These gases arrive /9
at afterburning chamber 14 and sweep burner 15. A part of the exhaust gases penetrates into burner 15 through openings 17 and, under the thermal action and photochemical effect of glow plugs 18 heated to red hot, undergoes endothermic dissociation involving carbon dioxide in particular; and then it flows through opening 19, mixing according to arrows A with the rest of the exhaust gases and with the additional air present in afterburning chamber 14. In the mixture thus formed, an exothermic recombination occurs, particularly of the carbon dioxide, in the form of a very hot flame which propagates, to the whole mixture which is present, a reaction leading to almost complete combustion, of the unburned substances and of the carbon monoxide which are present with the help of the additional air.

The hot mixture, now for the most part cleaned, then comes in to contact with catalytic elements 20 and 21, passing between them and partially through them, and there it is subjected to a catalytic cracking action which decomposes the last residues of unburned substances, to a catalytic oxidation action involving the possible residues of carbon monoxide, to a catalytic

action decomposing the nitrogen oxides and transforming them into noncontaminating elements, and to a chemical action which transforms the sulfur compounds into solid powdery substances. The set of disks 20 and rings 21 at the same time constitutes a reducer of powdery materials, which functions either partially by filtration, due to the permeability of the catalytic elements, or by deflection of the flow; in this way, the elimination of the gases is obtained, particularly that of the lead oxides derived from the combustion of the anti-knock substances possibly contained in the fuel which is used, and of the powdery sulfur compounds. Furthermore, the passage through catalytic elements 20 and 21 also gives rise to extensive attenuation of the noise of the gases; this noise is finally attenuated later by spirally wound perforated metallic leaf 24, which gives rise to this attenuation without appreciable dispersion of energy. /10

Finally, the gases leave through channel elements 25 and 26. Springs 28 are planned so as to balance the pressure exerted by the exhaust gases on channel elements 25 and 26 under medium operating conditions. At higher speeds, this pressure increases and brings about a mutual moving apart of channel elements 25 and 26, thus increasing the flow cross section rather than the speed of the gases, and therefore advantageously reducing the exhaust back pressure.

When passages 29 are provided, a laminar flow of air runs around the main flow of the exhaust gases, thus forming a sort of cushion between the exhaust gases and the ambient air, with the result of reducing the turbulences, resistances and noise, and of advantageously cooling the mobile parts of the flow adaptor.

In effect, the phenomena briefly described do not take place continuously but in a number of operating states, inside the device, a dynamic working state of pressure oscillations is established which propagates alternately in both longitudinal directions; the function of nonreturn valve 3-5 is precisely that of deflecting the pressure waves when they come from the interior, preventing their back flow and promoting the establishment of said dynamic working state of pressure oscillations, similar to that of a pulse jet.

By virtue of the characteristics and behaviors which have been described, the device according to the invention makes it possible to effectively clean exhaust gases, with elimination of the contaminating substances which they contain, and at the same time, to effectively attenuate the vibrations and consequently the noise. As a result, the device according to the invention, although it is suitable for more general applications, is particular useful for cleaning and muffling the exhaust of internal combustion engines. It should be noted that, for the reasons indicated above, the device according to the invention is capable of effectively cleaning the exhaust of Diesel engines and of installations in general in which fuel oils are burned, which up to now were practically excluded from any possibility of effective cleaning. /11

A particular advantage is obtained in the application to engines of this type mounted on vehicles, because in this case, the thrust exerted by the exhaust gases flowing from the device

can be used for providing additional propulsive thrust. In this regard, it must be noted that the structure, described as being that of a muffler-cleaner capable of also providing a propulsive thrust, can also be used, if necessary, to increase the propulsive effect by opportunely injecting a flow of atomized or gaseous liquid fuel into the afterburning chamber.

Naturally, different modifications can be made on the components which have been described. Thus, for example, as thermal elements in the burner in the burner, instead of ceramic glow plugs, it is possible to use other types of special electrical resistors, or either elements in the shape of a bar or other shape, heated by induction. The body of the burner can be produced of materials other than stainless steel, for example and advantageously, of quartz. Instead of the channel elements which were described, the flow adaptor can have other variable surface area arrangements, for example, a system with multiple lamellae similar to that used in the exhaust of propulsion turbojets.

Claims

1. An exhaust muffler-cleaner, particularly for internal combustion engines, of the type in which the exhaust gases not only are regularized in their flow conditions in order to reduce noise but are also subjected to afterburning for the purpose of eliminating their unburned parts, and to catalytic action aiming to eliminate the harmful substances, characterized by the fact that it mainly includes first intake (1) for the exhaust gases to be treated, second intake (2) with nonreturn valves (3-5) for additional air, said second intake (2) being arranged in the form of a ring around first intake (1), axial suction fan (7) arranged so as to act with its central portion in association with said first intake (1), and with its peripheral portion in association with said second intake (2), afterburning chamber (14) arranged so as to receive the confluence of the flows coming from said first and second intakes (1, 2), a burner arranged in said afterburning chamber, said burner being in the form of hollow (15) body with intake (17) and outlet (19) openings and containing thermal elements (18) electrically heated to the temperature of light emission, a set of catalytic elements (20, 21) arranged downstream from said afterburning chamber (14), and flow adaptor (25, 26); as well as thermally and acoustically insulated casing (30, 31) whose internal walls are aerodynamically shaped so as to follow the transformations of the gases passing through the different parts of the device.

2. An exhaust muffler-cleaner according to Claim 1, intended for a vehicle, characterized by the fact that said second intake (2) is arranged so that a stagnation pressure produced by the wind from the travel of the vehicle acts on it.

3. An exhaust muffler-cleaner according to Claim 1, characterized by the fact that suction fan (7) is planned to exert its maximum action at medium speed (such as 60% of the maximum speed) of the engine for which the device is intended. /13

4. An exhaust muffler-cleaner according to Claim 1, characterized by the fact that series of radial blades (9, 12, 11) for orientation of the flow and for mechanical support of components are arranged in said first (1) and second (2) intakes and downstream from said fan (7).

5. An exhaust muffler-cleaner according to Claim 1, characterized by the fact that said burner (15) is in the form of a body made of stainless steel containing nickel.

6. An exhaust muffler-cleaner according to Claim 1, characterized by the fact that said burner (15) is in the form of a body made of quartz.

7. An exhaust muffler-cleaner according to Claim 1, characterized by the fact that said thermal elements (18) are in the form of ceramic glow plugs containing electrical heating resistors.

8. An exhaust muffler-cleaner according to Claim 1, characterized by the fact that said thermal elements (18) are in the form of elements heated by induction.

9. An exhaust muffler-cleaner according to Claim 1, characterized by the fact that said set (20-21) of catalytic elements is in the form of a series of disks (20) and rings (21) arranged in an alternating manner, which are formed by a permeable sintered material of hollow spheroidal globules of copper or copper alloy.

10. An exhaust muffler-cleaner according to Claim 1, characterized by the fact that /14
installed downstream from the set (20-21) of catalytic elements is a nondissipative noise dampening component, formed by a spiral perforated metallic leaf spring.

11. An exhaust muffler-cleaner according to Claim 1, characterized by the fact that said flow adaptor (25-26) has mobile elements (25 and 26) acted upon elastically and moved by the pressure of the exiting gases.

12. An exhaust muffler-cleaner according to Claim 11, characterized by the fact that said flow adaptor (25-26) is delimited by two elements (25 and 26) mutually fitted together, applied towards one another by elastic components (28), with a pressure corresponding to the action exerted by the exhaust gases under medium operating conditions.

13. An exhaust muffler-cleaner according to Claim 1, characterized by the fact that air passages (29) are arranged so as to guide a lamellar flow of ambient air around said flow adaptor (25-26).

14. An exhaust muffler-cleaner according to Claim 1, characterized by the fact that said casing (30-31) of the device is mainly made up of two shells (30 and 31) juxtaposed according to an axial plane and connected together peripherally while enclosing the internal components.

15. An exhaust muffler-cleaner according to Claim 14, characterized by the fact that certain parts of said shells (30, 31) are connected in a removable manner in order to allow access to internal components.

16. An exhaust muffler-cleaner according to Claim 14, characterized by the fact that said shells (30, 31) are double walled, and that, between the external wall and the internal wall, they enclose thermally and acoustically insulating material (33). /15

17. An exhaust muffler-cleaner according to Claim 14, characterized by the fact that arranged around afterburning chamber (14) is subsequent wall (34) surrounding shells (30, 31) of the casing of the device a certain distance away from them.

18. An exhaust muffler-cleaner according to Claim 1, characterized by the fact that it has a means for supplying an atomized or gaseous liquid fuel, opening into the afterburning chamber in order to produce a propulsive thrust.

European Patent Office

Application Number EP 85 20 0876

EUROPEAN SEARCH REPORT

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.[4])
A	DE-A-2 163 537 (VOLKSWAGEN) * Page 6, line 7-page 8, line 31; figures 1, 2 * ---	1	F 01 N 3/24
A	US-A-2 985 255 (CLARK) * Column 2, line 29-column 3, line 52; figure 1 * ---	1	
A	DE-A-2 212 721 (SNOY) * Page 2, line 30-page 4, line 38; figures 1-3 * ---	1	
A	DE-A-2031 299 (APPCA) * Page 5, line 10-page 8, line 21; figure 1 * ---	1	
A	US-A-2 065 681 (FOGAS) * Page 1, left column, line 39-page 2, left column, line 28; figures 1-4 * ---	1	TECHNICAL FIELDS SEARCHED (Int. Cl.[4]) F 01 N
A	US-A-4 345 431 (SUZUKI) * Column 4, line 64-column 6, line 62; figures 2, 3 * ---	1	
A	DE-A-2 418 108 (UNIVERSAL OIL) * Page 7, line 1-page 9, line 19; figure 1 * ---	1	

The present search report has been drawn up for all claims.

Place of search	Date of completion of the search	Examiner
The Hague	September 20, 1985	M. Hakhverdi

CATEGORY OF CITED DOCUMENTS

X: Particularly relevant if taken alone.
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A: Technological background.
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E: Earlier patent document, but published on, or after the filing date.
D: Document cited in the application.
L: Document cited for other reasons.

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European Patent Office

Application Number EP 85 20 0876

EUROPEAN SEARCH REPORT

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.[4])
A	US-A-4 054 418 (MILLER) * Column 2, line 59-column 4, line 24; figure 1 * -----	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl.[4])
The present search report has been drawn up for all claims.			

Place of search	Date of completion of the search	Examiner
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D: Document cited in the application.
L: Document cited for other reasons.

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&: Member of the same patent family, corresponding document.

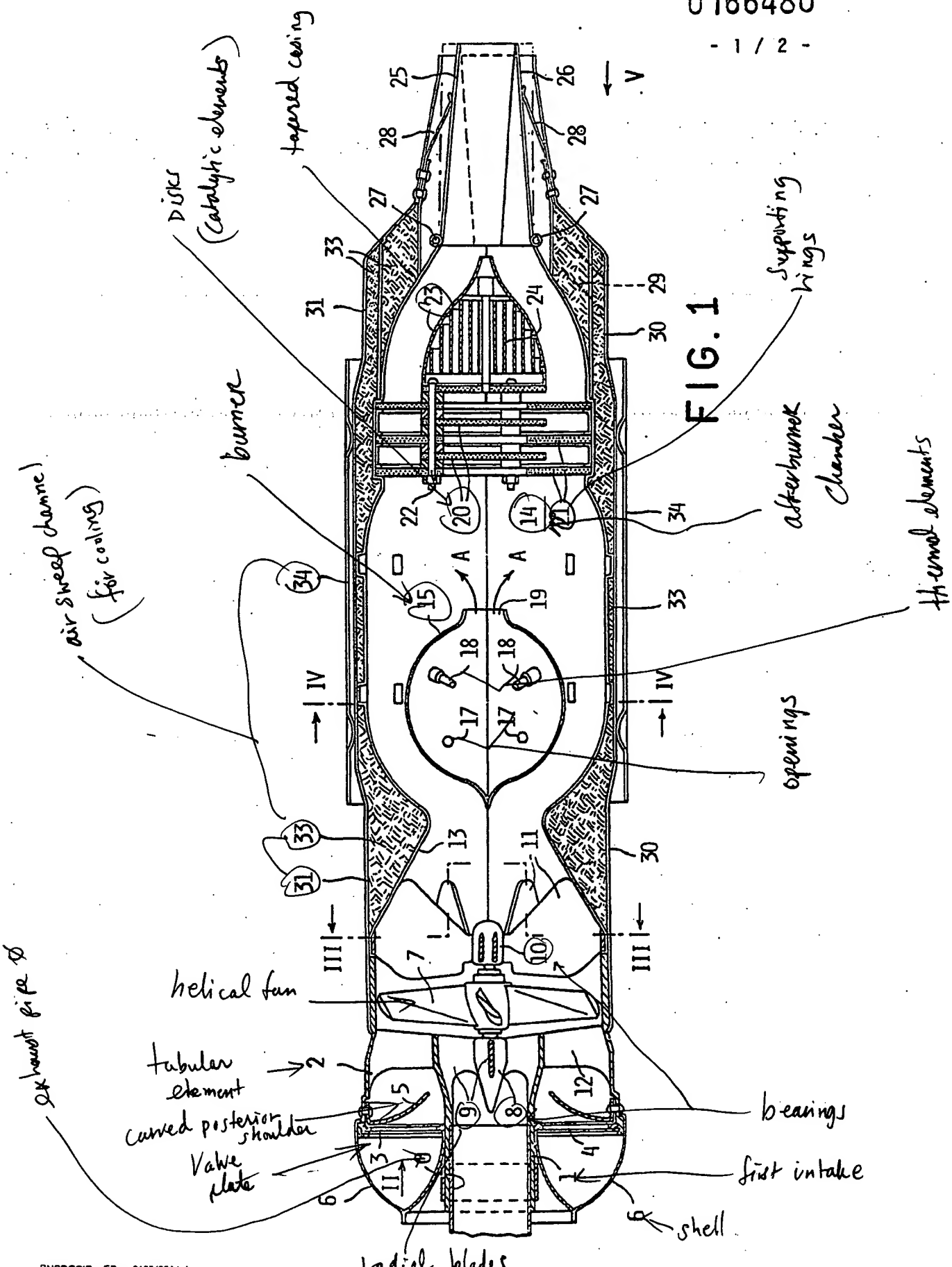

FIG. 1